

## Brackett- $\gamma$ Line Emission Maps of Four Galaxies

T.H. JARRETT, G. HELOU and C. A. BEICHMAN  
*IPAC/Caltech*

**Abstract.** Observations of the Br- $\gamma$  hydrogen recombination line have been made in a sample of four galaxies. The data were acquired with the new Palomar 30-inch Infrared Camera (PIRCAM) mounted at the prime focus (f/3.3) of the Hale 5-m telescope. The galaxies were imaged with narrow band filters centered on the Br- $\gamma$  (2.166  $\mu$ m) line and nearby K-band continuum. This project was undertaken with two goals in mind. First, to demonstrate the feasibility of extragalactic narrow-band imaging with near-infrared arrays, and second, to measure the Br- $\gamma$  to H $\alpha$  flux ratio corresponding to regions undergoing massive star formation. The galaxies are all at low redshift, but of a variety of morphologies: late-type galaxies, NGC 3683 (Sbc, 1656 km/s) and NGC 4713 (Sbd, 653 km/s), early-type galaxy, NGC 5866 (SO-I, 770 km/s), and irregular-type galaxy, NGC 2537 (IRR, 47 km/s). In three of the galaxies, NGC 2537, NGC 3683 and NGC 4713, we detect Br- $\gamma$  emission at the  $3\sigma$  level, and in NGC 5866 we obtain an upper limit. The spatial resolution of the raw 2.2  $\mu$ m data was about  $1''$ , with the final maps smoothed to a resolution of  $1 - 1.5''$ . Our Br- $\gamma$  detections resolve individual HII region complexes in the galaxies. By comparing the Br- $\gamma$  emission with H $\alpha$  emission, we may derive an effective extinction measure, and infer a Lyman continuum flux from massive stars. This Lyman luminosity can then be converted into a total mass estimate for young stars, assuming an initial mass function and an upper mass cut-off. To date we have acquired H $\alpha$  images of NGC 3683, NGC 4713, and NGC 5866. The preliminary results of NGC 4713 are presented in this paper.

**Key Words:** (is: Galaxies; Massive Star Formation; HII Regions

### 1. Observations and Data

Narrow-band (1%) filters were used to measure the Br- $\gamma$  line emission relative to the 2  $\mu$ m continuum. The Br- $\gamma$  ( $V = 0$  km/s) filter is centered at 2.163  $\mu$ m with a half-maximum bandwidth of 0.029  $\mu$ m and a maximum transmission of  $\sim 70\%$ . The red-shifted Br- $\gamma$  line center ranges from 35% filter transmission (NGC 3683) to 65% transmission for the other three galaxies. The filter used for the continuum subtraction is centered at 2.208  $\mu$ m with a FWHM of 0.024  $\mu$ m and 65% transmission.

The 2  $\mu$ m continuum images were then flux calibrated to the Br- $\gamma$  images using both standard stars and field stars located within the images containing the galaxies. The flux-calibrated continuum images were subtracted from the Br- $\gamma$  images resulting in a measure of the flux solely due to Br- $\gamma$  line emission. The H $\alpha$  data were acquired using the Palomar 60" telescope and a Tek1024 CCD camera. We used a red-shifted H $\alpha$  filter (0.660  $\mu$ m, FWHM = 0.01  $\mu$ m) and a broad-band R filter to measure the red continuum.

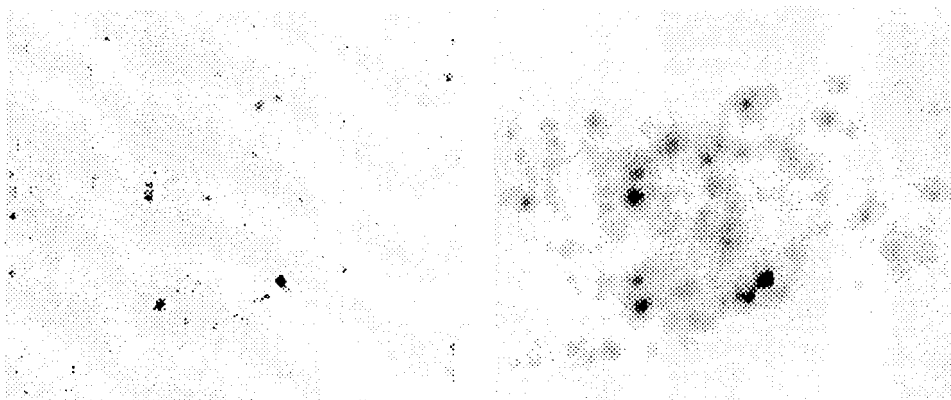


Fig. 1. NGC 4713 as seen in Br- $\gamma$  and H $\alpha$  line emission

## 2. NGC 4713 Results

By comparing the flux ratios between the H II recombination lines Br- $\gamma$  and H $\alpha$  we may estimate the intervening dust extinction. In Figure 1 we show the Br- $\gamma$  line emission image (on the left) and the H $\alpha$  line emission image (on the right). The individual H II regions are clearly detected in H $\alpha$ . Most of the H $\alpha$  clumps also have Br- $\gamma$  features with at least  $>2\sigma$  detections (in a  $5''$  aperture). The Br- $\gamma$  to H $\alpha$  flux ratios for the 15-20 clumps indicate visual extinctions of  $A_V = 0-3$ . This result is consistent with NGC 4713's "face-on" spiral-disk inclination, as well as its relative deficiency in gas and dust ( $\log L_{\text{IR}}/L_B \sim -0.1$ ).

## 3. Summary

We have observed the Br- $\gamma$  hydrogen recombination line in a sample of four galaxies using PFIRCAM and the Hale 5-m PF telescope. In three of the galaxies, irregular NGC 2537, edge-on spiral NGC 3683 and face-on spiral NGC 4713, we detect Br- $\gamma$  emission at the  $>2\sigma$  level. Our Br- $\gamma$  and H $\alpha$  detections resolve individual H II region complexes. The Br- $\gamma$  to H $\alpha$  flux ratios are consistent with extinctions  $< 3 A_V$  in NGC 4713, and from 4-7  $A_V$  in NGC 3683. Our preliminary results show that narrow-band Br- $\gamma$  imaging is quite feasible with the latest generation of near-ir arrays, and is a particularly powerful method of inferring visual extinction (to correct the H $\alpha$  flux) toward starburst or dusty galaxies ( $A_V > 5$ ).